DESCRIPTION

HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATIONS

This application is an application filed under 35 U.S.C. §111(a) claiming the benefit pursuant to 35 U.S.C. §119(e)(1) of the filing dates of Provisional Applications No. 60/486,897 and No. 60/486,898 both filed July 15, 2003 pursuant to 35 U.S.C. §111(b).

TECHNICAL FIELD

The present invention relates to heat exchangers, and more particularly to heat exchangers suitable for use as the evaporators of motor vehicle air conditioners which are refrigeration cycles to be installed in motor vehicles.

The term "aluminum" as used herein and in the appended claims includes aluminum alloys in addition to pure aluminum.

BACKGROUND ART

Heretofore in wide use as motor vehicle evaporators are those of the so-called stacked plate type which comprise a plurality of flat hollow bodies arranged in parallel and each composed of a pair of dishlike plates facing toward each other and brazed to each other along peripheral edges thereof, and a louvered corrugated fin disposed between and brazed to each adjacent pair of flat hollow bodies. In recent years, however, it has been demanded to provide evaporators further reduced

in size and weight and exhibiting higher performance.

To meet such a demand, the present applicant has already proposed evaporators which comprise a refrigerant inlet-outlet tank and a refrigerant turn tank arranged as spaced apart from each other, and a plurality of tube groups arranged in two rows as spaced apart in the direction of passage of air through the evaporator between the tanks and each comprising a plurality of heat exchange tubes arranged in parallel at a spacing longitudinally of the tanks, the heat exchange tubes of each tube group having opposite ends joined to the respective tanks, the refrigerant inlet-outlet tank having its interior divided by a partition wall into a refrigerant inlet header chamber and a refrigerant outlet header chamber arranged in the direction of passage of air, the two header chambers being in communication with the heat exchange tubes of the respective two tube groups, a refrigerant flowing into the inlet header chamber of the refrigerant inlet-outlet tank being flowable through the corresponding heat exchange tubes into the refrigerant turn tank, where the refrigerant changes its course to flow into the outlet header chamber of the refrigerant inlet-outlet tank through the corresponding heat exchange tubes, the outlet header chamber having its interior divided into a first space in communication with the corresponding heat exchange tubes and a second space for the refrigerant to flow out therefrom, by a partition plate having refrigerant passing holes (see the publication of JP-A No. 2003-75024). With this evaporator, the partition plate having the refrigerant passing holes and provided inside the outlet header

chamber functions to permit the refrigerant to flow through the heat exchange tubes of the two tube groups in uniform quantities, thereby enabling the evaporator to exhibit improved heat exchange performance.

However, extended research conducted by the present inventors has revealed that the evaporator disclosed in the above publication still remains to be improved in making the refrigerant to flow through the heat exchange tubes of the tube groups in uniform quantities and in heat exchange performance.

An object of the present invention is to overcome the above problem and to provide a heat exchanger which is outstanding in heat exchange performance.

DISCLOSURE OF THE INVENTION

To fulfill the above object, the present invention comprises the following modes.

1) A heat exchanger comprising a refrigerant inlet-outlet tank and a refrigerant turn tank arranged as spaced apart from each other, and a plurality of tube groups in the form of rows arranged at a spacing in the direction of flow of air through the heat exchanger between the tanks and each comprising a plurality of heat exchange tubes arranged in parallel at a spacing longitudinally of the tanks, the heat exchange tubes of each tube group having opposite ends joined to the respective tanks, the refrigerant inlet-outlet tank having interior divided by a partition wall into a refrigerant inlet header chamber and a refrigerant outlet header chamber

arranged in the direction of flow of air, each of the two header chambers being in communication with the heat exchange tubes of the tube group of at least one row, a refrigerant flowing into the inlet header chamber of the refrigerant inlet-outlet tank being flowable through the corresponding heat exchange tubes into the refrigerant turn tank, where the refrigerant changes its course to flow into the outlet header chamber of the refrigerant inlet-outlet tank through the corresponding heat exchange tubes,

the refrigerant turn tank being provide with a uniformalizing member for making uniform divided flows of the refrigerant from the inlet header chamber into the heat exchange tubes communicating with the inlet header chamber.

2) A heat exchanger described in par. 1) wherein the uniformalizing member comprises a divided flow control plate dividing the interior of the refrigerant turn tank into two spaces arranged in the direction of flow of air, the two spaces being in communication with each other, the heat exchange tubes in communication with the inlet header chamber communicating with one of the spaces of the refrigerant turn tank, the heat exchange tubes in communication with the outlet header chamber communicating with the other space of the refrigerant turn tank.

3) A heat exchanger described in par. 2) wherein the divided flow control plate has one or at least two refrigerant passing holes formed therein, and the two spaces are held in communication through the refrigerant passing holes.

4) A heat exchanger described in par. 3) wherein the

refrigerant flows through the refrigerant passing holes in the divided flow control plate in countercurrent relation with the flow of air.

5) A heat exchanger described in par. 3) wherein the divided flow control plate has two refrigerant dam portions at respective opposite end portions thereof and is provided between the two refrigerant dam portions with a refrigerant passing portion having one or at least two refrigerant passing holes, the length of each of the refrigerant dam portions being at least 15% of the entire length of the divided flow control plate, the combined area of all the refrigerant passing holes formed in the refrigerant passing portion being 130 to 510 mm^2.

6) A heat exchanger described in par. 3) wherein the divided flow control plate has two refrigerant dam portions at respective opposite end portions thereof and is provided between the two refrigerant dam portions with a refrigerant passing portion having one or at least two refrigerant passing holes, the length of each of the refrigerant dam portions being at least 15% of the entire length of the divided flow control plate, the heat exchanger being 20 to 75% in opening ratio which is the ratio of the number of refrigerant passing holes formed in the refrigerant passing portion to the number of heat exchange tubes of each tube group.

7) A heat exchanger described in par. 3) wherein the divided flow control plate has two refrigerant dam portions at respective opposite end portions thereof and is provided between the two refrigerant dam portions with a refrigerant

passing portion having one or at least two refrigerant passing holes, the length of each of the refrigerant dam portions being at least 15% of the entire length of the divided flow control plate, the combined area of all the refrigerant passing holes formed in the refrigerant passing portion being 130 to 510 mm^2, the heat exchanger being 20 to 75% in opening ratio which is the ratio of the number of refrigerant passing holes formed in the refrigerant passing portion to the number of heat exchange tubes of each tube group.

8) A heat exchanger described in par. 2) wherein the refrigerant turn tank comprises a first member of aluminum having the heat exchange tubes joined thereto, and a second member of an aluminum extrudate brazed to the first member at a portion thereof opposite to the heat exchange tubes, and the divided flow control plate is integral with the second member.

9) A heat exchanger described in par. 1) wherein the outlet header chamber of the refrigerant inlet-outlet tank has interior divided by a partition plate into a first space communicating with the corresponding heat exchange tubes and a second space for the refrigerant to flow out therefrom, the two spaces being in communication with each other.

10) A heat exchanger described in par. 9) wherein the partition plate has one or at least two refrigerant passing holes formed therein, and the two spaces are held in communication through the refrigerant passing holes.

11) A heat exchanger described in par. 9) wherein the refrigerant inlet-outlet tank comprises a first member of

aluminum having the heat exchange tubes joined thereto, and a second member of an aluminum extrudate brazed to the first member at a portion thereof opposite to the heat exchange tubes, and the partition wall and the partition plate are integral with the second member.

12) A heat exchanger described in par. 9) wherein the refrigerant inlet-outlet tank is provided at one end thereof with a refrigerant inlet communicating with the inlet header chamber and a refrigerant outlet communicating with the second space of the outlet header chamber.

13) A heat exchanger described in par. 1) wherein each tube group comprises at least seven heat exchange tubes.

14) A refrigeration cycle comprising a compressor, a condenser and an evaporator, the evaporator being a heat exchanger described in any one of par. 1) to 13).

15) A vehicle having installed therein a refrigeration cycle described in par. 14) as an air conditioner.

16) A heat exchanger comprising a refrigerant inlet-outlet tank and a refrigerant turn tank arranged as spaced apart from each other, and a plurality of tube groups in the form of rows arranged at a spacing in the direction of flow of air through the heat exchanger between the tanks and each comprising a plurality of heat exchange tubes arranged in parallel at a spacing longitudinally of the tanks, the heat exchange tubes of each tube group having opposite ends joined to the respective tanks, the refrigerant inlet-outlet tank having interior divided by a partition wall into a refrigerant inlet header chamber and a refrigerant outlet header chamber

arranged in the direction of flow of air, each of the two header chambers being in communication with the heat exchange tubes of the tube group of at least one row, a refrigerant flowing into the inlet header chamber of the refrigerant inlet-outlet tank being flowable through the corresponding heat exchange tubes into the refrigerant turn tank, where the refrigerant changes its course to flow into the outlet header chamber of the refrigerant inlet-outlet tank through the corresponding heat exchange tubes,

the inlet header chamber of the refrigerant inlet-outlet tank having interior divided by a flow dividing resistance plate into a first space communicating with the corresponding heat exchange tubes and a second space for the refrigerant to flow in, the flow dividing resistance plate having one refrigerant passing hole formed therein.

17) A heat exchanger described in par. 16) wherein the refrigerant passing hole is formed at a longitudinal midportion of the flow dividing resistance plate.

18) A heat exchanger described in par. 16) wherein the refrigerant passing hole is positioned between a pair of heat exchange tubes adjacent to each other longitudinally of the refrigerant inlet-outlet tank and included among the heat exchange tubes in communication with the inlet header chamber of the refrigerant inlet-outlet tank.

19) A heat exchanger described in par. 16) wherein the refrigerant passing hole has an area larger than the combined cross sectional area of refrigerant channels in one heat exchange tube.

20) A heat exchanger described in par. 16) wherein the refrigerant passing hole is circular and has a diameter of 3 to 8 mm.

21) A heat exchanger described in par. 16) wherein the refrigerant inlet-outlet tank has a wall portion to which the heat exchange tubes communicating with the first space are joined and which has a flow dividing member inwardly projecting from a part thereof corresponding to the refrigerant passing hole for causing the refrigerant to dividedly flow longitudinally of the inlet header chamber upon flowing through the refrigerant passing hole.

22) A heat exchanger described in par. 21) wherein the flow dividing member is a ridge projecting toward the resistance plate in the form of an angle and extending widthwise of the inlet header chamber.

23) A heat exchanger described in par. 16) wherein the outlet header chamber of the refrigerant inlet-outlet tank has interior divided by a partition plate into a first space communicating with the corresponding heat exchange tubes and a second space for the refrigerant to flow out therefrom, and a refrigerant passing hole is formed in the partition plate.

24) A heat exchanger described in par. 23) wherein the refrigerant inlet-outlet tank comprises a first member of aluminum having the heat exchange tubes joined thereto, and a second member of an aluminum extrudate brazed to the first member at a portion thereof opposite to the heat exchange tubes, and the partition wall, the flow dividing resistance plate and the partition plate are integral with the second member.

25) A heat exchanger described in par. 16) wherein the refrigerant inlet-outlet tank is provided at one end thereof with a refrigerant inlet communicating with the second space of the inlet header chamber and a refrigerant outlet communicating with the outlet header chamber.

26) A heat exchanger described in par. 16) wherein the refrigerant turn tank has interior divided by a divided flow control plate into a first space in communication with the heat exchange tubes communicating with the first space of the inlet header chamber of the refrigerant inlet-outlet tank and a second space communicating with the heat exchange tubes communicating with the outlet header chamber of the refrigerant inlet-outlet tank, and the divided flow control plate has a refrigerant dam portion at a position corresponding to the refrigerant passing hole in the flow dividing resistance plate with respect to the longitudinal direction of the two tanks, the divided flow control plate being provided with a refrigerant passing portion having a refrigerant passing hole at a position other than the dam portion.

27) A heat exchanger described in par. 26) wherein the refrigerant dam portion of the divided flow control plate has a length of at least 28 mm.

28) A heat exchanger described in par. 26) which is 20 to 90% in opening ratio which is the ratio of the number of refrigerant passing holes formed in the divided flow control plate to the number of heat exchange tubes in each tube group.

29) A heat exchanger described in par. 26) wherein the refrigerant turn tank comprises a first member of aluminum

having the heat exchange tubes joined thereto, and a second member of an aluminum extrudate brazed to the first member at a portion thereof opposite to the heat exchange tubes, and the divided flow control plate is integral with the second member.

30) A refrigeration cycle comprising a compressor, a condenser and an evaporator, the evaporator being a heat exchanger described in any one of par. 16) to 29).

31) A vehicle having installed therein a refrigeration cycle described in par. 30) as an air conditioner.

With the heat exchangers described in par. 1) to 4), the divided flow uniformalizing member acts to cause the refrigerant to flow through the heat exchange tubes connected to the inlet header chamber of the inlet-outlet tank in uniform quantities, i.e., uniform rates, enabling the heat exchanger to exhibit improved heat exchange performance.

With the heat exchangers described in par. 5) to 7), the refrigerant can be passed through the heat exchange tubes connected to the inlet header chamber of the refrigerant inlet-outlet tank in uniform quantities, permitting the heat exchanger to achieve an improved heat exchange efficiency.

In the case of the heat exchanger described in par. 8), the divided flow control plate of the refrigerant turn tank is formed integrally with the second member of aluminum extrudate. The control plate can therefore be provided inside the refrigerant turn tank by a simple procedure.

With the heat exchangers described in par. 9) and 10), the partition plate functions to cause the refrigerant to flow

through the heat exchange tubes connected to the inlet header chamber of the refrigerant inlet-outlet tank in uniform quantities and through the heat exchange tubes connected to the outlet header chamber of the inlet-outlet tank also in uniform quantities, consequently enabling the heat exchanger to exhibit further improved heat exchange performance.

Since the partition wall and partition plate of the refrigerant inlet-outlet tank are formed integrally with the second member in the heat exchanger described in par. 11), the partition wall and partition plate can be provided inside the inlet-outlet tank by a simple procedure.

In the case where the refrigerant inlet-outlet tank is provided at one end thereof with a refrigerant inlet communicating with the inlet header chamber and a refrigerant outlet communicating with the second space of the outlet header chamber as in the heat exchanger described in par. 12), the refrigerant flows through the heat exchange tubes of the tube groups markedly unevenly, whereas even in this case, the refrigerant flow through the heat exchange tubes can be made uniform when the heat exchanger has the feature described in any one of par. 1) to 7), 9) and 10).

In the case where each tube group comprises at least seven heat exchange tubes as in the heat exchanger described in par. 13), the refrigerant flows through the heat exchange tubes of the tube groups markedly unevenly, whereas even in this case, the refrigerant flow through the heat exchange tubes can be made uniform if the heat exchanger has the feature described in any one of par. 1) to 7), 9) and 10).

With the heat exchanger described in par. 16), the refrigerant is admitted into the second space of the inlet header chamber of the refrigerant inlet-outlet tank, flows through the single refrigerant passing hole in the flow dividing resistance plate into the first space, from which the refrigerant dividedly flows through all the heat exchange tubes communicating with the inlet header chamber. Because the resistance plate has only one refrigerant passing hole formed therein, the refrigerant gently flows from the second space into the first space to spread over the entire area of the first space and flow into all the heat exchange tubes. Accordingly, the refrigerant is allowed to flow through the heat exchange tubes communicating with the inlet header chamber of the inlet-outlet tank in uniform quantities, enabling the heat exchanger to exhibit improved heat exchange performance.

With the heat exchangers described in par. 17) to 20), the heat exchange tubes communicating with the inlet header chamber of the refrigerant inlet-outlet tank are made further uniform in the quantities of refrigerant flowing therethrough, permitting the heat exchanger to achieve an improved heat exchange efficiency.

The heat exchangers described in par. 21) and 22) are so adapted that the refrigerant flowing through the refrigerant passing hole of the flow dividing resistance plate can be made to spread over the entire area of the first space of the inlet header chamber with a high efficiency. The heat exchange tubes communicating with the inlet header chamber of the refrigerant inlet-outlet tank are therefore made uniform to a greater extent

in the quantities of refrigerant flowing therethrough, permitting the heat exchanger to achieve an improved heat exchange efficiency.

With the heat exchanger described in par. 23), the refrigerant changes its course inside the refrigerant turn tank, flows into the first space of the outlet header chamber of the refrigerant inlet-outlet tank, flows through the refrigerant passing holes of the partition plate into the second space. The resistance offered by the partition plate to the flow of refrigerant serves to further uniformalize the divided flows from the first space of the inlet header chamber into the heat exchange tubes communicating therewith, also uniformalizing the divided flows from the refrigerant turn tank into the heat exchange tube communicating therewith. Consequently, the refrigerant is made to flow through the heat exchange tubes of all the tube groups in uniform quantities for the heat exchange to exhibit improved heat exchange performance.

With the heat exchanger described in par. 24), the partition wall, flow dividing resistance plate and partition plate are formed integrally with the second member. This facilitates the procedure for providing the partition wall, flow diving resistance plate and partition plate inside the refrigerant inlet-outlet tank.

When the refrigerant inlet-outlet tank is provided at one end thereof with a refrigerant inlet communicating with the inlet header chamber and a refrigerant outlet communicating with the outlet header chamber as in the heat exchanger described

in par. 25), the refrigerant flows through the heat exchange tubes of the tube groups markedly unevenly, whereas even in this case, the refrigerant flow through the heat exchange tubes can be made uniform if the heat exchanger has the feature described in any one of par. 16) to 23).

The heat exchangers described in par. 26) to 28) have a refrigerant dam portion which offers resistance to the refrigerant flowing from the first space of the inlet header chamber of the refrigerant inlet-outlet tank into the first space of the refrigerant turn tank via the corresponding heat exchange tubes. The heat exchange tubes communicating with the inlet header chamber of the inlet-outlet tank are therefore made uniform to a greater extent in the quantities of refrigerant flowing therethrough.

In the heat exchanger described in par. 29), the divided flow control plate of the refrigerant turn tank is formed integrally with the second member of aluminum extrudate. Accordingly, the control plate can be provided inside the turn tank by a facilitated procedure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the overall construction of a first embodiment of evaporator according to the invention. FIG. 2 is a view in vertical section partly broken away and showing the evaporator of FIG. 1 as it is seen from behind. FIG. 3 is a view in section taken along the line A-A in FIG. 2. FIG. 4 is an enlarged view in section taken along the line B-B in FIG. 2 and partly broken away. FIG.

5 is an enlarged view in section taken along the line C-C in FIG. 2 and partly broken away. FIG. 6 is an exploded perspective view of a refrigerant inlet-outlet tank of the evaporator of FIG. 1. FIG. 7 is an exploded perspective view of a refrigerant turn tank of the evaporator of FIG. 1. FIG. 8 is a diagram showing how a refrigerant flows through the evaporator of FIG. 1. FIG. 9 is a view corresponding to FIG. 8 and showing a second embodiment of evaporator according to the invention. FIG. 10 is a view corresponding to FIG. 8 and showing a third embodiment of evaporator according to the invention. FIG. 11 is a view corresponding to FIG. 8 and showing a fourth embodiment of evaporator according to the invention. FIG. 12 is a view corresponding to FIG. 8 and showing a fifth embodiment of evaporator according to the invention. FIG. 13 is a view corresponding to FIG. 2 and showing a sixth embodiment of evaporator according to the invention. FIG. 14 is a view in horizontal section of a refrigerant inlet-outlet tank showing a seventh embodiment of evaporator according to the invention. FIG. 15 is an enlarged view in section taken along the line D-D in FIG. 14 and partly broken away. FIG. 16 is an exploded perspective view of a refrigerant inlet-outlet tank of the evaporator of the seventh embodiment. FIG. 17 is an exploded perspective view of a refrigerant turn tank of the evaporator of the seventh embodiment. FIG. 18 is a diagram showing how a refrigerant flows through the evaporator of the seventh embodiment. FIG. 19 is a diagram corresponding to FIG. 18 and showing an eighth embodiment of evaporator according to the invention. FIG. 20 is an enlarged fragmentary view

in vertical section showing a ninth embodiment of evaporator according to the invention.

BEST MODE OF CARRYING OUT THE INVENTION

Embodiments of the present invention will be described below with reference to the drawings. These embodiments are evaporators according to the invention.

In the following description, the upper, lower, left- and right-hand sides of FIGS. 1, 2 and 13 will be referred to respectively as the "upper," "lower," "left" and "right," the downstream side of the flow of air through an air passing clearance between each adjacent pair of heat exchange tubes (i.e., the direction indicated by the arrow X in FIG. 1, and the right-hand side of FIGS. 4, 5 and 15) will be referred to as "front," and the opposite side as "rear." Further throughout all the drawings, like parts will be designated by like reference numerals and will not be described repeatedly.

FIGS. 1 to 5 show the overall construction of an evaporator as a first embodiment of the invention, FIGS. 6 and 7 show the construction of main portions, and FIG. 8 shows how a refrigerant flows through the evaporator of the first embodiment.

With reference to FIGS. 1 to 3, the evaporator 1 comprises a refrigerant inlet-outlet aluminum tank 2 and a refrigerant turn aluminum tank 3 which are arranged as spaced apart vertically, tube groups 5 in the form of a plurality of rows, i.e., two rows in the present embodiment, as spaced forwardly or rearwardly of the evaporator between the two tanks 2, 3

and each comprising a plurality of heat exchange aluminum tubes 4, i.e., at least seven heat exchange aluminum tubes 4, arranged in parallel at a spacing leftwardly or rightwardly, i.e., laterally, of the evaporator, corrugated aluminum fins 6 arranged respectively in air passing clearances between adjacent pairs of heat exchange tubes 4 of each tube group 5 and also outside the heat exchange tubes 4 at the left and right opposite ends of each tube group 5 and each brazed to the heat exchange tube 4 adjacent thereto, and an aluminum side plate 7 disposed outside the corrugated fin 6 at each of the left and right ends.

With reference to FIGS. 4 to 6, the refrigerant inlet-outlet tank 2 comprises a platelike first member 8 made of aluminum brazing sheet having a brazing material layer at least over the outer surface (lower surface) thereof and having the heat exchange tubes 4 joined thereto, a second member 9 of bare aluminum extrudate and covering the upper side of the first member 8, and aluminum caps 11, 12 closing respective left and right end openings. The tank 2 comprises a refrigerant inlet header chamber 13 positioned on the front side and a refrigerant outlet header chamber 14 positioned on the rear side.

The first member 8 has at each of the front and rear side portions thereof a curved portion 15 in the form of a circular arc of small curvature in cross section and bulging downward at its midportion. The curved portion 15 has a plurality of tube insertion slits 16 elongated forward or rearward and arranged at a spacing in the lateral direction. Each

corresponding pair of slits 16 in the front and rear curved portions 15 are in the same position with respect to the lateral direction. The front edge of the front curved portion 15 and the rear edge of the rear curved portion 15 are integrally provided with respective upstanding walls 17 extending over the entire length of the member 8. The first member 8 includes between the two curved portions 15 a flat portion 18 having a plurality of through holes 19 arranged at a spacing in the lateral direction.

The second member 9 is generally m-shaped in cross section and opened downward and comprises front and rear two walls 21, 22 extending laterally, a partition wall 23 provided in the midportion between the two walls 21, 22 and extending laterally to divide the interior of the refrigerant inlet-outlet tank 2 into front and rear two spaces, and two generally circular-arc connecting walls 24 bulging upward and integrally connecting the partition wall 23 to the respective front and rear walls 21, 22 at their upper ends. The rear wall 22 and the partition wall 23 are integrally interconnected at their lower ends by a partition plate 25 over the entire length of the member 9. Alternatively, a plate separate from the rear wall 22 and the partition wall 23 may be secured to these walls 22, 23 as the plate 25. The partition plate 25 has laterally elongated refrigerant passing holes 26, 26A formed therein at a rear portion thereof other than the left and right end portions of the plate and arranged at a spacing laterally thereof. The refrigerant passing hole 26A in the lateral midportion of the plate 25 has a length smaller than the spacing

between adjacent heat exchange tubes 4 of the rear tube group 5, and is formed between the adjacent two heat exchange tubes 4 in the lateral middle of the rear tube group 5. The other refrigerant passing holes 26 have a larger length than the hole 26A. The partition plate 25 is provided at a rear edge portion of its lower surface with a downwardly projecting ridge 25a integral therewith and extending over the entire length thereof. The front wall 21 is integrally provided at the lower edge of its inner surface with a ridge 21a projecting downward. The partition wall 23 has a lower end projecting downward beyond the lower ends of the ridges 21a, 25a and integrally provided with a plurality of projections 23a fitted into the through holes 19 of the first member 8, these projections 23a projecting downward from the lower edge of the wall 23 and arranged at a spacing in the lateral direction. The projections 23a are formed by cutting away specified portions of the partition wall 23.

The caps 11, 12 are made from a bare material as by press work, forging or cutting, each have a recess facing laterally inward for the corresponding ends of the first and second members 8, 9 to fit in. The right cap 12 has a refrigerant inflow opening 12a in communication with the refrigerant inlet header chamber 13, and a refrigerant outflow opening 12b communicating with the upper portion of the refrigerant outlet header chamber 14 above the partition plate 25. Brazed to the right cap 12 is a refrigerant inlet-outlet aluminum member 27 having a refrigerant inlet 27a communicating with the refrigerant inflow opening 12a and a refrigerant outlet 27b communicating

with the refrigerant outflow opening 12b.

The two members 8, 9 are brazed to each other utilizing the brazing material layer of the first member 8, with the projections 23a of the second member 9 inserted in the respective holes 19 of the first member 8 in crimping engagement and with the upstanding walls 17 of the first member 8 engaged with the ridges 21a, 25a of the second member 9. The refrigerant inlet-outlet tank 2 is formed by brazing the two caps 11, 12 to the first and second members 8, 9 using a brazing material sheet. The portion of the tank 2 forwardly of the partition wall 23 of the second member 9 serves as the refrigerant inlet header chamber 13, and the portion thereof rearward from the partition wall 23 as the refrigerant outlet header chamber 14. Furthermore, the refrigerant outlet header chamber 14 is divided into upper and lower two spaces 14a, 14b by the partition plate 25, and these spaces 14a, 14b are in communication through the refrigerant passing holes 26, 26A. The lower space 14b is a first space in communication with the heat exchange tubes 4 of the rear tube group 5, and the upper space 14a a second space via which the refrigerant flows out of the evaporator. The refrigerant outflow opening 12b of the right cap 12 is in communication with the upper space 14a of the refrigerant outlet header chamber 14.

With reference to FIGS. 4, 5 and 7, the refrigerant turn tank 3 comprises a platelike first member 28 made of aluminum brazing sheet having a brazing material layer at least over the outer surface (upper surface) thereof and having the heat exchange tubes 4 joined thereto, a second member 29 made of

bare aluminum extrudate and covering the lower side of the first member 28, and aluminum caps 31 for closing left and right opposite end openings. The tank 3 comprises a refrigerant inflow header chamber 32 as a space positioned on the front side and a refrigerant outflow header chamber 33 as a space positioned on the rear side.

The refrigerant turn tank 3 has a top surface 3a, front and rear opposite side surfaces 3b and a bottom surface 3c. The top surface 3a of the refrigerant turn tank 3 is circular-arc in cross section in its entirety such that the midportion thereof with respect to the forward or rearward direction is the highest portion 34 which is gradually lowered toward the front and rear sides. The tank 3 is provided in its front and rear opposite side portions with grooves 35 extending from the front and rear opposite sides of the highest portion 35 of the top surface 3a to the front and rear opposite side surfaces 3b, respectively, and arranged laterally at a spacing. Each groove 35 has a flat bottom face. Each groove 35 has a first portion 35a existing on the top surface 3a of the tank 3 and having the same depth over the entire length of this portion. Opposite side faces defining the first portion 35a of the groove 35 are inclined upwardly outward away from each other laterally of the tank 3, and the width of the first portion 35a of the groove 35 gradually increases from the bottom of the groove toward the opening thereof. Further in the longitudinal section of each groove 35, the bottom face of the first portion 35a is shaped in the form of a circular arc extending from the highest portion (34) side of the tank top surface 3a forwardly or rearwardly

outward as curved downward.

The groove 35 has a second portion 35b existing at the junction 3d of the top surface 3a of the refrigerant turn tank 3 and the front or rear side surface 3b thereof and having a bottom face which is inclined downward forwardly or rearwardly outward. The bottom face of the second portion 35b extends from the end of the bottom face of the first portion 35a. Each groove 35 has a third portion 29c existing on the front or rear side surface 3b of the tank 3 and having a vertical bottom face. The groove third portion 35c has the same width from the bottom of the groove 35 to the opening thereof.

The first member 28 has a circular-arc cross section bulging upward at its midportion with respect to the forward or rearward direction and is provided with a depending wall 28a formed at each of the front and rear side edges thereof integrally therewith and extending over the entire length of the member 28. The upper surface of the first member 28 serves as the top surface 3a of the refrigerant turn tank 3, and the outer surface of the depending wall 28a as the front or rear side surface 3b of the tank 3. The grooves 35 are formed in each of the front and rear side portions of the first member 28 and extend from the highest portion 34 in the midportion of the member 28 with respect to the forward or rearward direction to the lower end of the depending wall 28a. In each of the front and rear side portions of the first member 28 other than the highest portion 34 in the midportion thereof, tube insertion slits 36 elongated in the forward or rearward direction are formed between respective adjacent pairs of grooves 35.

Each corresponding pair of front and rear tube insertion slits 36 are in the same position with respect to the lateral direction. The first member 28 has a plurality of through holes 37 formed in the highest portion 34 in the midportion thereof and arranged laterally at a spacing. The depending walls 28a, grooves 35, tube insertions slits 36 and through holes 37 of the first member 28 are formed at the same time by making the member 28 from an aluminum brazing sheet by press work.

The second member 29 is generally w-shaped in cross section and opened upward, and comprises front and rear two walls 38, 39 curved upwardly outwardly forward and rearward, respectively, and extending laterally, a vertical partition wall 41 dividing the interior of the refrigerant turn tank 3 into front and rear two spaces, and two connecting walls 42 integrally connecting the partition wall 41 to the respective front and rear walls 38, 39 at their lower ends. The outer surfaces of the connecting walls 42 provide the bottom surface 3c of the tank 3, and the outer surfaces of the front and rear walls 38, 39 each provide a junction 3e of the bottom surface 3c and the front or rear side surface 3b. The front and rear walls 38, 39 have respective ridges 38a, 39a each projecting upward from the inner edge of the upper end thereof and extending over the entire length of the wall.

The partition wall 41 has an upper end projecting upward beyond the upper ends of the front and rear walls 38, 39, and is provided with a plurality of projections 41a projecting upward from the upper edge of the wall 41 integrally therewith, arranged laterally at a spacing and to be fitted into the

respective through holes 37 in the first member 28. The partition wall 41 is provided, at a portion thereof slightly leftwardly of its midportion, with refrigerant passing cutouts 41b formed in the upper edge thereof between respective adjacent pairs of projections 41a. The projections 41a and the cutouts 41b are formed by cutting away specified portions of the partition wall 41.

The caps 31 are made from a bare material as by press work, forging or cutting, and each have a recess facing laterally inward for the corresponding ends of the first and second members 28, 29 to fit in.

The first and second members 28, 29 are brazed to each other utilizing the brazing material layer of the first member 28, with the projections 41a of the second member 29 inserted through the respective holes 37 in crimping engagement and with the depending walls 28a of the first member 28 engaged with the ridges 38a, 39a of the second member 29. The two caps 31 are further brazed to the first and second members 28, 29 using a brazing material sheet, whereby the refrigerant turn tank 3 is formed. The upper-end openings of the cutouts 41b in the partition wall 41 of the second member 29 are closed with the first member 28, whereby refrigerant passing holes 43 are formed. The refrigerant passing holes 43, which are formed by closing the upper-end openings of the cutouts 41b in the partition wall 41 with the first member 28, can alternatively be through holes formed in the partition wall 41. The partition wall 41 of the second member 29 serves as a divided flow control plate 44 which has the refrigerant passing

holes 43 and which functions as a uniformalizing member dividing the refrigerant turn tank 3 into the refrigerant inflow header chamber 32 on the front side and the refrigerant outflow header chamber 33 on the rear side for causing the refrigerant to flow as uniformly divided.

The divided flow control plate 44 is provided at its left and right opposite end portions with respective refrigerant dam portions 45A, 45B having no refrigerant passing holes 43 and each extending from the corresponding end of the plate 44 over a predetermined length. Between the dam portions 45A, 45B, the plate 44 has a refrigerant passing portion 46 provided with one or at least two refrigerant passing holes 43, i.e., at least two refrigerant passing holes 43 in this embodiment. The dam portion 45B at the right has a length which is greater than that of the dam portion 45A at the left and approximately one-half of the entire length of the control plate 44. It is desired that the length of each of the dam portions 45A, 45B be at least 15% of the entire length of the control plate 44, and that the combined area of all the refrigerant passing holes 43 formed in the refrigerant passing portion 46 be 130 to 510 mm^2. Preferably, the length of each of the refrigerant dam portions 45A, 45B is limited to not greater than 78% of the entire length of the control plate 44 if largest. The ratio of the number of refrigerant passing holes 43 in the refrigerant passing portion 46 to the number of heat exchange tubes 4 of each tube group 5, i.e., the opening ratio, is preferably 20 to 75%. If the length of each dam portion 45A or 45B is less than 15% of the entire length of the divided flow control

plate 44, it is likely that all the heat exchange tubes 4 of each tube group will not be fully uniform in the amount of flow of the refrigerant therethrough. Further if the combined area of all the refrigerant passing holes 43 in the refrigerant passing portion 46 is less than 130 mm^2, greatly increased channel resistance will be offered to result in adversely affected performance, whereas if the combined area is in excess of 510 mm^2, there is the likelihood that the control plate 44 will be unable to serve the divided flow control function. If the opening ratio, i.e., the ratio of the number of refrigerant passing holes 43 in the refrigerant passing portion 46 to the number of heat exchange tubes 4 of each tube group 5, is less than 20%, greatly increased channel resistance will be encountered to entail adversely affected performance. If the ratio is over 75%, it is likely that no divided flow control function will be available.

The heat exchange tubes 4 providing the front and rear tube groups 5 are each made of a bare material in the form of an aluminum extrudate. Each tube 4 is flat, has a large width in the forward or rearward direction and is provided in its interior with a plurality of refrigerant channels 4a extending longitudinally of the tube and arranged in parallel. The tube 4 has front and rear opposite end walls which are each in the form of an outwardly bulging circular arc. Each corresponding pair of heat exchange tube 4 of the front tube group 5 and heat exchange tube 4 of the rear tube group 5 are in the same position with respect to the lateral direction. Each heat exchange tube 4 has its upper end inserted into the

tube insertion slit 16 of the first member 8 of the inlet-outlet tank 2 and brazed to the first member 8 utilizing the brazing material layer of the member 8, and has its lower end inserted into the tube insertion slit 36 of the first member 28 of the turn tank 3 and brazed to the first member 28 utilizing the brazing material layer of the member 28.

Preferably, the heat exchange tube 4 is 0.75 to 1.5 mm in height, i.e., in thickness in the lateral direction, 12 to 18 mm in width in the forward or rearward direction, 0.175 to 0.275 mm in the wall thickness of the peripheral wall thereof, 0.175 to 0.275 mm in the thickness of partition walls separating refrigerant channels 4a from one another, 0.5 to 3.0 mm in the pitch of partition walls, and 0.35 to 0.75 mm in the radius of curvature of the outer surfaces of the front and rear opposite end walls.

In place of the heat exchange tube 4 of aluminum extrudate, an electric resistance welded tube of aluminum may be used which has a plurality of refrigerant channels formed therein by inserting inner fins into the tube. Also usable is a tube which is made from a plate prepared from an aluminum brazing sheet having an aluminum brazing material layer on opposite sides thereof by rolling work and which comprises two flat wall forming portions joined by a connecting portion, a side wall forming portion formed on each flat wall forming portion integrally therewith and projecting from one side edge thereof opposite to the connecting portion, and a plurality of partition forming portions projecting from each flat wall forming portion integrally therewith and arranged at a spacing widthwise

thereof, by bending the plate into the shape of a hairpin at the connecting portion and brazing the side wall forming portions to each other in butting relation to form partition walls by the partition forming portions. The corrugated fins to be used in this case are those made from a bare material.

The corrugated fin 6 is made from an aluminum brazing sheet having a brazing material layer on opposite sides thereof by shaping the sheet into a wavy form. Louvers 6a are formed as arranged in parallel in the forward or rearward direction in the portions of the wavy sheet which connect crest portions thereof to furrow portions thereof. The corrugated fins 6 are used in common for the front and rear tube groups 5. The width of the fin 6 in the forward or rearward direction is approximately equal to the distance from the front edge of the heat exchange tube 4 in the front tube group 5 to the rear edge of the corresponding heat exchange tube 4 in the rear tube group 5. It is desired that the corrugated fin 6 be 7.0 mm to 10.0 mm in fin height, i.e., the straight distance from the crest portion to the furrow portion, and 1.3 to 1.8 mm in fin pitch, i.e., the pitch of connecting portions.

The evaporator 1 is fabricated by tacking the components together in combination and collectively brazing the tacked assembly.

Along with a compressor, a condenser and pressure reduction means, the evaporator 1 constitutes a refrigeration cycle, which is installed in vehicles, for example, in motor vehicles for use as an air conditioner.

With reference to FIG. 8 showing the evaporator 1

described, a two-layer refrigerant of vapor-liquid mixture phase flowing through a compressor, condenser and pressure reduction means enters the refrigerant inlet header chamber 13 of the refrigerant inlet-outlet tank 2 via the refrigerant inlet 27a of the refrigerant inlet-outlet member 27 and the refrigerant inflow opening 12a of the right cap 12.

The refrigerant admitted into the inlet header chamber 13 tends to readily flow into the heat exchange tubes 4 closer to the left and right opposite ends of the front tube group 5, whereas since the divided flow control plate 44 of the refrigerant turn tank 3 has the refrigerant dam portions 45A, 45B at its opposite ends, these dam portions offer resistance to the refrigerant to be passed through the heat exchange tubes 4 closer to the left and right ends, permitting the refrigerant to flow as uniformly divided into the tubes 4, flow down the refrigerant channels 4a therein and ingress into the refrigerant inflow header chamber 32 of the refrigerant turn tank 3.

The refrigerant then flows into the refrigerant outflow header chamber 33 through the refrigerant passing holes 43 of the refrigerant passing portion 46, dividedly moves into the refrigerant channels 4a of all the heat exchange tubes 4 of the rear tube group 5, changes its course and passes upward through the channels 4a into the lower space 14b of the refrigerant outlet header chamber 14 of the refrigerant inlet-outlet tank 2. The partition plate 25 provided in the outlet header chamber 14 gives resistance to the flow of refrigerant, consequently enabling the refrigerant to flow

as uniformly divided from the outflow header chamber 33 into the tubes 4 of the rear tube group 5 and also to flow from the inlet header chamber 13 into the tubes 4 of the front tube group 5. As a result, the refrigerant flows through the heat exchange tubes 4 of the two tube groups in uniform quantities.

Subsequently, the refrigerant flows through the refrigerant passing holes 26, 26A of the partition plate 25 into the upper space 14a of the outlet header chamber 14 and flows out of the evaporator via the refrigerant outflow opening 12b of the cap 12 and the outlet 27b of the refrigerant inlet-outlet member 27. While flowing through the refrigerant channels 4a of the heat exchange tubes 4 of the front tube group 5 and the refrigerant channels 4a of the heat exchange tubes 4 of the rear tube group 5, the refrigerant is subjected to heat exchange with air flowing through the air passing clearances in the direction of arrow X shown in FIG. 1 and flows out of the evaporator in a vapor phase.

At this time, water condensate is produced on the surfaces of the corrugated fins 6, and the condensate flows down the top surface 3a of the turn tank 3. The condensate flowing down the tank top surface 3a enters the first portions 35a of the grooves 35 by virtue of a capillary effect, flows through the grooves 35 and falls off the lower ends of the groove third portions 35c to below the turn tank 3. This prevents a large quantity of condensate from collecting between the top surface 3a of the turn tank 3 and the lower ends of the corrugated fins 6, consequently preventing the condensate from freezing due to the collection of large quantity of the condensate,

whereby inefficient performance of the evaporator 1 is precluded.

According to the first embodiment, the divided flow control plate 44 has the refrigerant passing holes 43 and divides the refrigerant turn tank 3 into the refrigerant inflow header chamber 32 on the front side and the refrigerant outflow header chamber 33 on the rear side to serve as a uniformalizing member for causing the refrigerant to flow as uniformly divided through the heat exchange tubes 4 of the front tube group 5 in communication with the inlet header chamber 13. However, this construction is not limitative but can be modified suitably.

FIG. 9 shows a second embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 9, the divided flow control plate 44 within the refrigerant turn tank 3 has a refrigerant passing portion 46 at the lateral midportion thereof, and refrigerant dam portions 45A, 45B provided respectively on the left and right sides of this portion 46 and approximately equal in length. This embodiment is the same as the first embodiment with respect to the ratio of the length of each of the dam portions 45A, 45B to the entire length of the control plate 44, the combined area of all the refrigerant passing holes 43 formed in the refrigerant passing portion 46, and the opening ratio which is the ratio of the number of refrigerant passing holes 43 formed in the refrigerant passing portion 46 to the number of heat exchange tubes 4 in each tube group 5. The partition plate 25 of the refrigerant inlet-outlet tank 2 has a plurality of laterally elongated refrigerant passing holes 50 arranged laterally at a spacing and formed at the

portions thereof corresponding to the respective dam portions 45A, 45B of the divided flow control plate 44. All the refrigerant passing holes 50 are equal in length. The second embodiment is the same as the first with the exception of these features.

The second embodiment is also so adapted that the refrigerant flowing through the evaporator flows through the heat exchange tubes 4 of each tube group in uniform quantities.

FIG. 10 shows a third embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 10, the divided flow control plate 44 within the refrigerant turn tank 3 has a refrigerant passing portion 46 slightly longer than in the first embodiement and positioned leftwardly of the lateral midportion thereof, and refrigerant dam portions 45A, 45B provided respectively on the left and right sides of this portion 46. The dam portion 45B at the right has a length greater than that of the dam portion 45A at the left and approximately one-half of the entire length of the control plate 44. This embodiment is the same as the first embodiment with respect to the ratio of the length of each of the dam portions 45A, 45B to the entire length of the control plate 44, the combined area of all the refrigerant passing holes 43 formed in the refrigerant passing portion 46, and the opening ratio which is the ratio of the number of refrigerant passing holes 43 formed in the refrigerant passing portion 46 to the number of heat exchange tubes 4 in each tube group 5. The partition plate 25 of the refrigerant inlet-outlet tank 2 has one laterally

elongated refrigerant passing hole 51 formed at the portion thereof corresponding to the left dam portion 45A of the control plate 44, and a plurality of laterally elongated refrigerant passing holes 51 arranged laterally at a spacing and formed at the portion thereof corresponding to the right dam portion 45B. All the refrigerant passing holes 51 are equal in length. The third embodiment is the same as the first with the exception of these features.

The third embodiment is also so adapted that the refrigerant flowing through the evaporator flows through the heat exchange tubes 4 of each tube group in uniform quantities.

FIG. 11 shows a fourth embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 11, the divided flow control plate 44 within the refrigerant turn tank 3 has an auxiliary refrigerant passing hole 60 formed in at least one of the two refrigerant dam portions 45A, 45B, i.e., in each of these dam portions 45A, 45B according to the present embodiment. The fourth embodiment is the same as the first with the exception of this feature. Also in the second and third embodiments, an auxiliary refrigerant passing hole may be formed in at least one of the two dam portions 45A, 45B.

The fourth embodiment is also so adapted that the refrigerant flowing through the evaporator flows through the heat exchange tubes 4 of each tube group in uniform quantities.

FIG. 12 shows a fifth embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 12, an evaporator

61 has a refrigerant inlet-outlet tank 32 and a refrigerant turn tank 3 which are made to extend rightward over a larger distance than is the case with the first embodiment. Provided between these extensions 2A, 3A are tube groups 5 in the form of front and rear two rows and each comprising a plurality of heat exchange tubes arranged in parallel at a spacing in the lateral direction. The front and rear tube groups 5 have their heat exchange tubes 4 joined at the tube upper ends to the respective front and rear opposite side portions of the extensions 2A of the tank 2 and at the tube lower ends to the respective front and rear opposite side portions of the extensions 3A of the tank 3.

The outlet header chamber 14 of the refrigerant inlet-outlet tank 2 has no partition plate. The extension 2A of the tank 2 has right-end openings which are closed with a cap (not shown) having no refrigerant inflow opening and no refrigerant outflow opening. The two header chambers 32, 33 of the refrigerant turn tank 3 are separated from the extensions 32A, 33A of these chambers 32, 33 by a partition plate 62. The extension 3A of the tank 3 has right-end openings which are closed with a cap (not shown) having a refrigerant inflow opening and a refrigerant outflow opening. Brazed to this cap is a refrigerant inlet-outlet member (not shown) having a refrigerant inlet in communication with the inflow opening and a refrigerant outlet in communication with the outflow opening. The fifth embodiment is the same as the first with the exception of these features. The first to fourth embodiments can also be given the same construction as the fifth embodiment.

A two-layer refrigerant of vapor-liquid mixture phase flowing through a compressor, condenser and pressure reduction means enters the evaporator 61, more specifically, the extension 32A of the refrigerant inflow header chamber 32 of the refrigerant turn tank 3 via the refrigerant inlet of the refrigerant inlet-outlet member and the refrigerant inflow opening of the right cap.

The refrigerant admitted into the extension 32A flows upward through the refrigerant channels 4a of heat exchange tubes 4 of the front tube group 5 joined to the extension 3A, flows into the refrigerant inlet header chamber 13 and flows leftward through this chamber 13. As in the case of the first embodiment, the refrigerant thereafter flows as uniformly divided into the heat exchange tubes 4 of the front tube group 5, flows down the refrigerant channels 4a therein and ingresses into the refrigerant inflow header chamber 32 of the refrigerant turn tank 3.

The refrigerant then flows into the refrigerant outflow header chamber 33 through the refrigerant passing holes 43 of the refrigerant passing portion 46, dividedly moves into the refrigerant channels 4a of all the heat exchange tubes 4 of the rear tube group 5, changes its course and passes upward through the channels 4a into the refrigerant outlet header chamber 14 of the refrigerant inlet-outlet tank 2. Subsequently, the refrigerant flows rightward through the outlet header chamber 14, enters the channels 4a of heat exchange tubes 4 of the rear tube group 5 joined to the extension 2A, flows down the channels 4a into the extension 33A of the outflow header chamber

33 of the turn tank 3 and flows out of the evaporator through the refrigerant outflow opening of the cap and the outlet of the inlet-outlet member.

The fifth embodiment is also so adapted that the refrigerant flowing through the evaporator flows through the heat exchange tubes 4 of each tube group in uniform quantities.

FIG. 13 shows a sixth embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 13, the refrigerant passing holes 43 formed in the divided flow control plate 44 are positioned as shifted from heat exchange tubes 4. Stated more specifically, each refrigerant passing hole 43 is positioned between a pair of adjacent heat exchange tubes 4. With the exception of this feature, the sixth embodiment is the same as the first. Incidentally, the second to fifth embodiments can be made to have the same construction as the sixth embodiment.

FIGS. 14 to 18 show a seventh embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIGS. 14 to 18, the front wall 21 and the partition wall 23 of the second member 9 of the refrigerant inlet-outlet tank 2 are connected together at their lower ends by a flow dividing resistance plate 70 over the entire length of the tank. The resistance plate 70 has one refrigerant passing circular hole 71 formed at the midportion thereof with respect to the lateral direction. Alternatively, the resistance plate 70 may be a plate separate from the front wall 21 and the partition wall 23 and fixed

to the front wall 21, rear wall 22 and partition wall 23. The refrigerant inlet header chamber 13 is divided by the resistance plate 70 into upper and lower two spaces 13a, 13b, which are held in communication with each other through the circular hole 71. The lower space 13b is a first space which is in communication with the heat exchange tubes 4 of the front tube group 5, and the upper space 13a is a second space for the refrigerant to flow in. The refrigerant inflow opening 12a of the right cap 12 is in communication with the upper space 13a of the inlet header chamber 13.

The refrigerant passing circular hole 71 of the flow dividing resistance plate 70 is positioned between the two heat exchange tubes 4 in the lateral center of the front tube group 5. The circular hole 71 has a lateral size (diameter) which is smaller than the spacing between the two tubes 4. Preferably, the hole 71 is 3 to 8 mm in diameter. If the hole 71 is less than 3 mm in diameter, increased channel resistance will be offered to the refrigerant to burden the air conditioner system with an increased load, while the flow of refrigerant produces a greater noise due to an increased flow velocity. If the diameter of the hole 71 is in excess of 8 mm, an increased quantity of refrigerant flows through the midportion, further entailing the likelihood that the refrigerant will encounter difficulty in spreading over the entire area of lower space 13b to be described below of the inlet header chamber 13. The refrigerant passing circular hole 71 has an area greater than the combined cross sectional area of refrigerant channels of one heat exchange tube 4. The refrigerant passing hole

to be formed in the flow dividing resistance plate 70 is not limited to the circular shape but may have a suitably altered shape, such as an elliptical form (not limited to a mathematically defined elliptical form but including forms which are nearly elliptical). Even when the refrigerant passing hole has a shape other than the circular, the hole should have the above-mentioned area and is so sized as to be positioned between the two heat exchange tubes in the lateral midportion of the tube group 5.

With reference to FIG. 17, the divided flow control plate 44 of the refrigerant turn tank 3 has a refrigerant dam portion 72 having no refrigerant passing holes and formed at the longitudinal midportion thereof, i.e., at a position corresponding to the refrigerant passing circular hole 71 of the flow dividing resistance plate 70 of the inlet-outlet tank 2. The control plate 44 also has a refrigerant passing portion 73 formed on each of the left and right sides of the dam portion 72 and having one or at least two refrigerant passing holes 43, i.e, at least two holes 43 in the present embodiment. Preferably, the dam portion 72 has a length of at least 28 mm in the lateral direction. If the length is less than 28 mm, it is likely that an increased amount of refrigerant will flow through the midportion. Further preferably, the ratio of the number of refrigerant passing holes 43 in each refrigerant passing portion 73 to the number of heat exchange tubes 4 of each tube group 5, i.e., the opening ratio, is 20 to 90%. If this ratio is less than 20%, increased channel resistance will be offered to the refrigerant, possibly resulting in

impaired performance. When the ratio is in excess of 90%, it is likely that no divided flow control function will be available.

The seventh embodiment is the same as the first with the exception of the above features.

With reference to FIG. 18 showing the evaporator 1 of the seventh embodiment, a two-layer refrigerant of vapor-liquid mixture phase flowing through a compressor, condenser and pressure reduction means enters the upper space 13a of the refrigerant inlet header chamber 13 of the refrigerant inlet-outlet tank 2 via the refrigerant inlet 27a of the refrigerant inlet-outlet member 27 and the refrigerant inflow opening 12a of the right cap 12, flows into the lower space 13b through the single circular hole 71 in the flow dividing resistance plate 70 and further flows from the lower space 13b dividedly into the refrigerant channels 4a of all the heat exchange tubes 4 of the front tube group 5. Since the resistance plate 70 has the single refrigerant passing circular hole 71 only formed therein, the refrigerant gently flows into the lower space 13b, spreads over the entire area of this space 13b to flow into the refrigerant channels 4a of all the heat exchange tubes 4. This permits the refrigerant to flow through these tube 4 in uniform quantities.

The refrigerant flowing into the channels 4a of all the heat exchange tubes 4 flows down the channels 4a into the refrigerant inflow header chamber 32 of the refrigerant turn tank 3. The refrigerant admitted into the chamber 32 flows leftwardly and righwardly outward by virtue of the function

of the dam portion 72 and flows into the refrigerant outflow header chamber 33 through the holes 43 of the refrigerant passing portions 73. The resistance offered by the dam portion 73 to the flow of refrigerant inhibits the refrigerant from flowing out of the lower space 13b of the header chamber 13 only into the channels 4a of the heat exchange tubes 4 of the front tube group 5 which tubes are positioned in the vicinity of the circular holes 71, while promoting the flow of refrigerant into the channels 4a of the other heat exchange tubes. Thus, the refrigerant is made to flow through the heat exchange tubes 4 of the front tube group 5 in uniform quantities.

The refrigerant flowing into the outflow header chamber 33 dividedly flows into the refrigerant channels 4a of all the heat exchange tubes 4 of the rear tube group 5, changes its course and passes upward through the channels 4a into the lower space 14b of the refrigerant outlet header chamber 14 of the refrigerant inlet-outlet tank 2. The partition plate 25 in chamber 14 gives resistance to the flow of refrigerant, consequently enabling the refrigerant to flow as uniformly divided from the outflow header chamber 33 into the tubes 4 of the rear tube group 5 and also to flow from the lower space 13b of the inlet header chamber 13 into the heat exchange tubes 4 of the front tube group 5. As a result, the refrigerant flows through the heat exchange tubes 4 of the two tube groups in uniform quantities.

Subsequently, the refrigerant flows through the refrigerant passing holes 26, 26A of the partition plate 25 into the upper space 14a of the outlet header chamber 14 and

flows out of the evaporator via the refrigerant outflow opening 12b of the cap 12 and the outlet 27b of the refrigerant inlet-outlet member 27. While flowing through the refrigerant channels 4a of the heat exchange tubes 4 of the front tube group 5 and the refrigerant channels 4a of the heat exchange tubes 4 of the rear tube group 5, the refrigerant is subjected to heat exchange with air flowing through the air passing clearances in the direction of arrow X shown in FIG. 1 and flows out of the evaporator in a vapor phase.

FIG. 19 shows an eighth embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 19, the partition plate 25 of the refrigerant inlet-outlet tank 2 has a plurality of laterally elongated refrigerant passing holes 26 arranged at a spacing in the lateral direction and formed at each of the portions thereof corresponding to the respective refrigerant passing portions 73 of the divided flow control plate 44. All the refrigerant passing holes 26 are equal in length. The eighth embodiment is the same as the seventh with the exception of this feature.

The eighth embodiment is also so adapted that the refrigerant flowing through the evaporator flows through the heat exchange tubes 4 of each tube group in uniform quantities.

FIG. 20 shows a ninth embodiment of evaporator according to the invention.

In the case of the embodiment shown in FIG. 20, the first member 8 of the refrigerant inlet-outlet tank 2 has an upwardly projecting ridge 75 in the form of an angle in cross section,

extending forward or rearward and positioned at the lateral midportion thereof immediately below the center, with respect to the lateral direction, of the refrigerant passing circular hole 71. The ridge 75 is formed by upwardly bending the first member 8 into a projecting ridge. In the forward or rearward direction, the length of the ridge 75 is preferably at least equal to the diameter (size in the forward or rearward direction) of the circular hole 71. The ridge 75 is a flow dividing member by which the refrigerant flowing from the upper space 13a of the inlet header chamber 13 into the lower space 13b thereof through the circular hole 71 is divided leftward and rightward within the space 13b. Incidentally, the ridge 75 is formed simultaneously when the first member 8 is made from an aluminum brazing sheet by press work. The ridge may be formed by fixing a separate member to the upper surface of the first member 8 instead of bending the first member 8 upward.

The ninth embodiment is the same as the seventh with the exception of the above feature.

In all the foregoing embodiments, one tube group 5 is provided between the front portions, as well as the rear portions, of the two tanks 2, 3, but this construction is not limitative; one or at least two tube groups 5 may be provided between the front portions, as well as the rear portions, of the tanks 2, 3. Further in all the foregoing embodiments, the highest portion 34 is positioned at the midportion, with respect to the forward or rearward direction, of the refrigerant turn tank 3, whereas this arrangement is not limitative; the highest portion may be located away from such midportion of the tank

3. One or at least two tube groups are provided at each of the front and rear sides of the highest portion also in this case. Although the refrigerant inlet-outlet tank 2 is positioned above the refrigerant turn tank 3 which is at a lower level according to all the foregoing embodiments, the evaporator may be used conversely with the turn tank 3 positioned above the inlet-outlet tank 2.

INDUSTRIAL APPLICABILITY

The heat exchanger of the present invention is suitable for use as an evaporator for motor vehicle air conditioners and is adapted to exhibit improved heat exchange performance.